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USERS MANUAL FOR C CLOUD S DATABASE

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AIR FORCE GEOPHYSICS LABORATORY  
AIR FORCE SYSTEMS COMMAND  
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This technical report has been reviewed and is approved for publication.

  
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## I. INTRODUCTION

This Users Manual provides detailed instructions for applications programmers to access and utilize a prototype computer-based global\* climatology of total sky cover cloud statistics known as "C Cloud S."

### A. Background

C Cloud S (Climatology of Cloud Statistics) makes available to engineers, systems designers, climatologists, and meteorologists a compact, automated, fast response database of mean sky cover and scale distance parameters (see Boehm, 1987). It is not a historical database; that is, what was observed on a given day is not available in C Cloud S. It is intended to provide the basic climatology input to stochastic sky cover simulators that generate sequences of observations statistically resembling sky cover observations.

C Cloud S was developed by ST Systems Corporation (STX) for the Atmospheric Sciences Division of the Air Force Geophysics Laboratory (AFGL). AFGL sponsored development of the database and the computer techniques necessary to use it for mapping global sky cover in recognition of their clear relevance and value to military weapon systems design (sky cover simulation modeling), deployment, and operations. In creating the database STX took full advantage of earlier studies at AFGL that established the algorithms and basic techniques for applying sky cover climatologies to the mapping of global sky cover.

\* Because of lack of data in the polar areas, sky cover statistics are provided for the region between 60° North and 60° South latitudes.

C Cloud S blends into one standardized set of statistics a variety of existing sky cover climatologies with various periods of record and based on various types of observations. The basis for this standardization is the work of Burger and Gringorten at AFGL.

Burger and Gringorten (1984) derived analytical expressions that use only two parameters (mean sky cover and scale distance) to calculate the complete distribution of sky cover as seen by a surface observer. Mean sky cover is defined as the single point probability of clouds averaged over an observer's sky dome. Scale distance is a measure of how fast the correlation of sky cover decays over distance. For example, for locations with predominantly cumulus sky cover the scale distance is quite small (0.4 km) while locations with predominantly stratiform sky cover have longer scale distances (5.0 km or greater). Burger (1985) derived values for these two parameters from approximately 2,000 sky cover distributions archived by various sources over the world which he analyzed by hand. He then plotted equal area maps of the parameters to produce a World Atlas of Total Sky Cover for visual reference on a global scale.

Burger tested the distribution at a wide variety of locations and found a 1.4% RMS difference between the observed sky cover distributions and his distribution. Thus the Burger distribution, using only the two parameters of mean sky cover and scale distance, not only gives an excellent description of the fractional sky cover climatology, but also permits extremely economical and efficient data storage.

## B. Organization

The first step taken by STX in automating mean sky cover and scale distance parameters to create the C Cloud S

database was to prepare the data for rapid and efficient processing. Section II details the data sources, processing procedures, and data file formats for the database. Then given the data in appropriately processed form, a prototype global sky cover mapping scheme was developed. Section III describes the prototype software. The mapping scheme developed is unique in that changes in sky cover distributions from location to location and in time take place gradually and are not categorized into sets of regions of rigid sky cover climatologies with defined boundaries, as is done in many cloud atlases.



## II. DEVELOPMENT OF THE C CLOUD S DATABASE

### A. Description of Burger Data Processing

When developing algorithms for computing sky cover frequency distributions, Burger (1985) computed and formatted on tape initial means and scale distance parameters for more than 2,000 stations around the world. This data ensemble of initial means and scale distance parameters ("Burger data") was made available to STX, which archived a common format for subsequent data processing, analysis, and sky cover mapping procedures.

The overall structure for processing the Burger data is depicted in Fig. 1. Detailed descriptions of the software to process these data and the data file format documentation follow.

Imbedded in the software are several subroutines developed by Harms (1986) that were extremely useful in initiating Burger's algorithms for computing sky cover climatologies. Much of the theory in Burger's model development of sky cover distributions was created by Gringorten (1979).

All software development and data file generation described in this manual was carried out using FORTRAN V on the AFGL Cyber 180/860 computer system.

1. PROGRAM NAME: CCOVR Version 1.0 3/5/87

PURPOSE: To read Burger data from tape to permanent disk file for subsequent interactive processing

INPUT: Magnetic Tape #4125  
1600 BPI

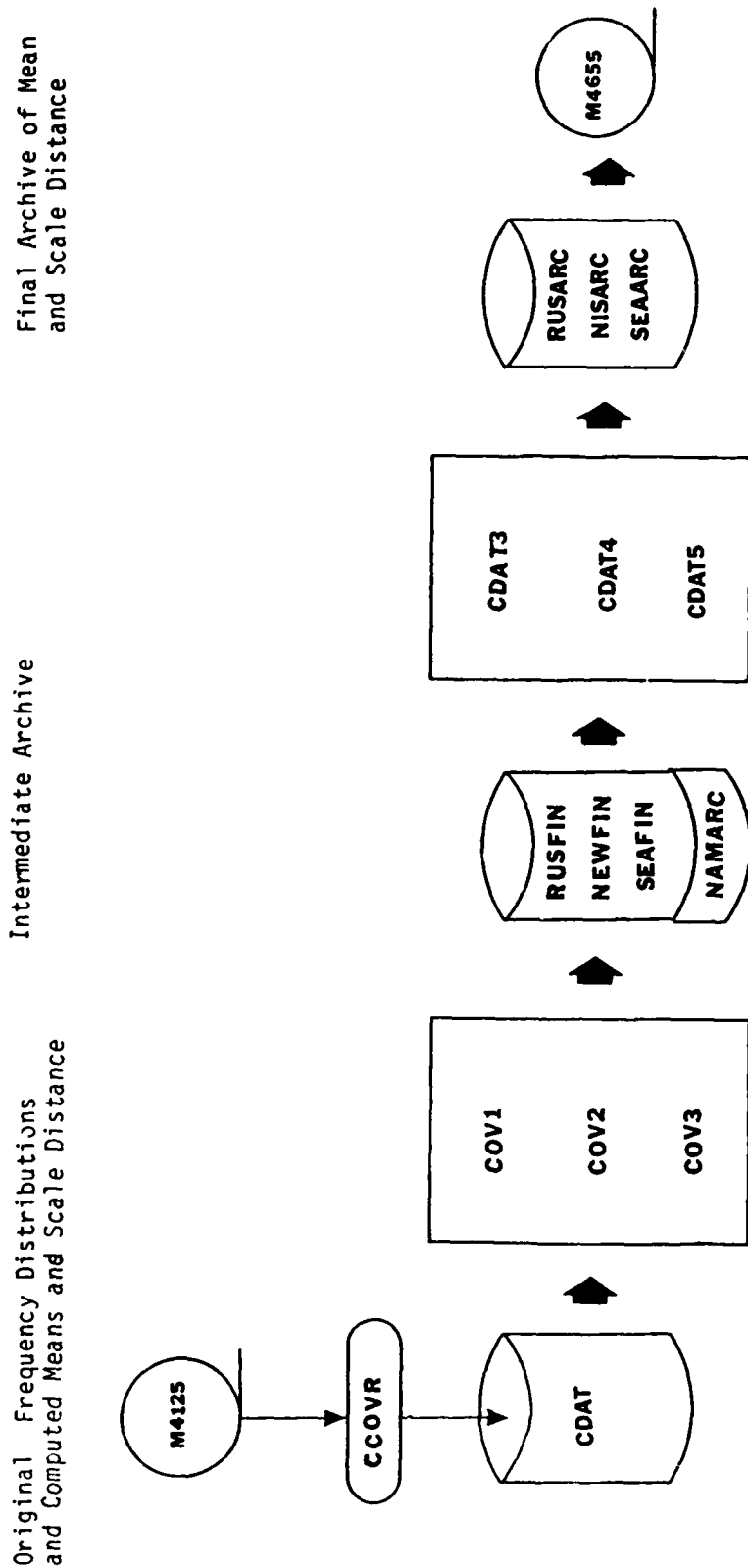


Fig. 1 Processing Configuration for Archiving Burger Data

Nine Track  
ASCII  
No Label Tape

OUTPUT: Permanent disk file named CDAT

REMARKS: Tape M4125, assembled by Burger (1985), contains names, locations, sky cover frequency distributions, means, and scale distance parameters for over 2,000 weather reporting stations around the world. The data on tape are assembled in three separate files.

CDAT file 1 contains sky cover data derived from 266 Revised Uniform Summaries of Weather Observations (RUSSOWs) obtained from the National Technical Information Service (NTIS).

CDAT file 2 contains locations and sky cover parameters compiled from ship weather observations. The main data source for this file was the NAV Atlas (NAVAIR 50-1C-528). The data are given in the form of cumulative percent frequency curves from 0- to 8-eighths sky cover. Some 222 daily averages of sky cover were averaged over the four mid-season months of January, April, July, and October.

CDAT file 3 is the largest data file, containing sky cover climatologies for 1846 stations world wide. Climate data from the National Intelligence Survey (NIS) were the main source of statistics for this file. The data consist of: a mean sky cover; the probability of being less than or equal to a certain fractional coverage, such as 2/8 or 3/10; and the probability of exceeding a certain coverage, such as 6/8 or 7/10.

FORMATS: Data for the first station in each of the three CDAT files are presented in Table 1.

TABLE 1. SAMPLE OUTPUT OF CDAT FILES

## CDAT FILE 1

1	1	FORT RUCKER, ALABAMA	AT 31 DEG, 16 MIN N	85 DEG, 43 MIN W	AT ELEVATION	93
JANUARY	.303	.026 .049	.030 .026 .015 .032 .029 .035	.026 9.999 .560		
JANUARY	.178	.037 .046	.034 .028 .018 .030 .032 .057	.055 9.999 .660		
JANUARY	.154	.040 .040	.036 .046 .027 .039 .048 .065	.075 9.999 .560		
JANUARY	.244	.050 .053	.036 .032 .026 .032 .038 .044	.035 9.999 .570		
APRIL	.371	.052 .042	.045 .031 .018 .029 .036 .053	.024 9.999 .450		
APRIL	.182	.047 .052	.047 .037 .031 .029 .046 .061	.062 9.999 .620		
APRIL	.156	.032 .035	.037 .040 .060 .054 .100 .117	.060 9.999 .630		
APRIL	.231	.050 .067	.064 .050 .041 .058 .070 .070	.040 9.999 .510		
JULY	.341	.066 .089	.078 .049 .036 .048 .049 .059	.032 9.999 .380		
JULY	.065	.059 .067	.077 .062 .043 .049 .083 .106	.095 9.999 .640		
JULY	.005	.007 .018	.042 .094 .090 .073 .140 .164	.102 9.999 .730		
JULY	.017	.022 .041	.034 .046 .042 .059 .101 .123	.108 9.999 .770		
OCTOBER	.553	.036 .034	.027 .021 .012 .022 .032 .032	.014 9.999 .320		
OCTOBER	.328	.084 .042	.043 .038 .025 .022 .034 .052	.055 9.999 .460		
OCTOBER	.248	.071 .067	.048 .061 .047 .038 .038 .075	.073 9.999 .490		
OCTOBER	.395	.079 .066	.041 .036 .024 .041 .037 .042	.022 9.999 .380		
3.34	2.55	1.81 2.55 2.77 1.89 1.18 1.54 1.24 .87	.44 .76 3.19 2.17 1.46 2.12			

## CDAT FILE 2

1	AT 61 DEG, 0 MIN N	65 DEG, 0 MIN W
JANUARY	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 9.999	
APRIL	0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 9.999	
JULY	.080 .130 .180 .270 .330 .380 .470 .530 .830 .660	
OCTOBER	.090 .120 .190 .240 .290 .310 .440 .560 .980 .660	
0.00	0.00 1.38 1.06	

## CDAT FILE 3

1001	AMSTERDAM, NETHERLANDS	AT 52 DEG, 19 MIN N	4 DEG, 47 MIN E	AT ELEVATION	5
JANUARY	2.00 8.00 .390 .230 .680 .190 .390 .710 .130 .350 .250 .190 .390 .710				
0.00	1.98 0.00 1.98				
APRIL	2.00 8.00 .400 .570 .520 .200 .500 .660 .170 .570 .650 .270 .630 .550				
2.95	1.29 .89 1.16				
JULY	2.00 8.00 .320 .580 .560 .160 .450 .690 .130 .520 .680 .190 .550 .600				
1.72	1.27 .85 1.10				
OCTOBER	2.00 6.00 .350 .550 .550 .190 .450 .660 .130 .420 .700 .190 .520 .630				
2.45	1.57 1.24 1.20				

The first line of an eighteen line record in file 1 contains station location information that can be read as follows:

```
      READ(NTAPE,8000) ISCODE,STNAME,LATDEG,LATMIN,LATDIR,  
      LONDEG,LONMIN,LONDIR,LEVAT  
8000  FORMAT(2X,I3,4A10,3X,I3,5X,I3,5X,A1,3X,  
      I3,5X,I3,5X,A1,5X,I5)
```

The variables have the following definitions:

ISCODE:	Burger Station Number
STNAME:	Station Name
LATDEG:	Latitude Degrees
LATMIN:	Minutes of Latitude
LATDIR:	N-North, S-South
LONDEG:	Longitude Degrees
LONMIN:	Minutes of Longitude
LONDIR:	E-East, W-West
LEVAT:	Station Elevation Meters above Sea Level

The next sixteen lines contain frequency of occurrence of sky cover categorized in tenths together with mean sky cover for four mid-season months averaged over the local standard time periods of 0000-0200, 0600-0800, 1200-1400, and 1800-2000 hours, respectively. The value in the overcast category is set to missing (9.999). The last value in each line is the mean sky cover parameter ( $P_0$ ). Use the following format statement to read these data lines:

```
      READ(NTAPE,8001)MONTH,(FREQ(J),J=1,10),DUM,P0  
8001  FORMAT(A10,F7.3,11F6.3)
```

Variables are:

MONTH:	Month of the Year
--------	-------------------

FREQ:        Normalized Sky Cover Frequency;  
              Ten Categories (0/10-9/10)  
 DUM:        Dummy Variables  
 P<sub>0</sub>:        Mean Sky Cover Probability

The final line in the record contains the sixteen scale distance values (r) in the following format:

```
      READ(NTAPE,8002) (R(J),J=1,16)
8002  FORMAT(10X,16F7.2)
```

The first four r values correspond to the first four January months, the next four to Aprils, etc.

CDAT file 2 contains sky cover data compiled from ship reports. The first line in this file contains location information that can be read using the following format:

```
      READ(NTAPE,9000) ISCODE, LATD, LATM, LATR, LOND, LONNM, LONR
9000  FORMAT(1X,I3,3X,I3,5X,I3,5X,A1,3X,I3,5X,I3,5X,A1)
```

The variables are:

ISCODE:      Burger Station Number  
 LATD:        Latitude Degrees  
 LATM:        Minutes of Latitude  
 LATR:        N-North, S-South  
 LOND:        Longitude Degrees  
 LONNM:       Minutes of Longitude  
 LONR:        E-East, W-West

Cumulative sky amount frequency distributions for nine sky cover categories for each of four mid-season months together with mean sky cover may be read next using:

```
      READ(NTAPE,9001) MONTH, (FREQ(J),J=1,9), P0
9001  FORMAT(1X,A10,10F6.3)
```

where:

MONTH: Month of Year  
FREQ(J): Cumulative Frequency Probability for Nine  
Sky Amount Categories  
P<sub>0</sub>: Mean Sky Cover Probability

The last line consists of scale distance parameters for the four mid-season months and is read using:

```
      READ(NTAPE,9002) (R(I),I=1,4)
9002  FORMAT(1X,4F7.2)
```

The first station in file 3 has nine lines of data. The first line defines NIS station location information that can be read using the following format:

```
      READ(NTAPE,9010) ISTA, (NAME(J),J=1,4),LAT,LATM,LA,
      LON,LONM,LO,IELEV
9010  FORMAT(3X,I7,4A10,4X,I3,5X,I3,5X,A1,1X,I5,5X,
      I3,5X,A1,14X,I7)
```

Variables are defined as:

ISTA: Burger Station Number  
NAME: Station Name  
LAT: Latitude  
LATM: Minutes of Latitude  
LA: N-North, S-South  
LON: Longitude  
LONM: Minutes of Longitude  
LO: E-East, W-West  
IELEV: Elevation of Station in Meters

Next, two lines of information are given for each of four mid-season months. The first line contains frequencies of sky cover amount and mean sky cover values in the following format:

```
      READ(NTAPE,9011)MONTH,F1,F2(PF1(J),PF2(J),P0(J),J=1,4)
9011  FORMAT(1X,A10,2F6.2,12F6.3)
```

The variables are:

MONTH: Month of Year

F1: Fractional Coverage Threshold One

F2: Fractional Coverage Threshold Two

PF1: Probability of Being  $\leq$  F1

PF2: Probability of Being  $>$  F2

P<sub>0</sub>: Mean Sky Cover Probability

J=1,4: Data Are Averaged Over the Four Local Standard  
Time Groups of 0000-0200, 0600-0800, 1200-1400,  
and 1800-2000

The second line consists of the four scale distance values  
computed and tabulated for the four local time groups defined  
above. These data parameters can be read using the following  
format statement:

```
      READ(NTAPE,9012)(R(J),J=1,4)
9012  FORMAT(1X,F6.2,3F7.2)
```

2. PROGRAM NAME: COV1, COV2, and COV3 Version 1.0 3/7/87

PURPOSE: To create preliminary formatting software and generate  
NAMARC file

INPUT: COV1 inputs data from CDAT file 1  
COV2 inputs data from CDAT file 2  
COV3 inputs data from CDAT file 3

OUTPUT: CDAT files are cleaned and separated into unique  
temporary files with names RUSFIN, NEWFIN, and SEAFIN. A fourth  
file call NAMARC is also created that contains only header



records describing station identification. Since period of record information was not archived in the original CDAT database, all data record sources were reviewed and wherever a period of record information was available it was edited into the appropriate NAMARC record.

Table 2 lists portions of the NAMARC data file. A NAMARC line can be read using the following format:

```
      READ(NTAPE,100)IREC,NUM,XLAT,XLON,(IP(J),J=1,4),NL,  
      ICM,ICS,IC,NAME,IEL  
100   FORMAT(2I5,F6.2,F7.2,4I2,I2,2I3,I1,3A10,A3,I6)
```

Variables for NAMARC format are:

IREC: Record Number  
NUM: Burger Station Number  
XLAT: Latitude (+ North, - South)  
XLON: Longitude (+ East, - West)  
IP: Period of Record; Right Justified (72 = 1972)  
NL: Number of Data Lines  
ICM: Number of Mean Sky Cover Values  
ICS: Number of Scale Distance Parameters  
IC: Data Code (1) RUSARC, (2) NISARC, (3) SEAARC,  
(4) DATARC  
NAME: Station Name  
IEL: Station Elevation in Meters above Sea Level

3. PROGRAM NAME: CDAT3, CDAT4, and CDAT5 Version 1.0 3/15/87

PURPOSE: To archive all station locations and means and scale distance parameters into a final common format suitable for optimum future processing applications

INPUT: CDAT3 inputs data from file RUSFIN  
CDAT4 inputs data from file NEWFIN  
CDAT5 inputs data from file SEAFIN

TABLE 2. NAMARC SAMPLE OUTPUT

1	1	31.27	-85.725470	0	0	8	16	161	FORT RUCKER, ALABAMA	93
2	2	51.88	-176.6346655068	8	15	151	151	ADAK, ALASKA	5	
3	3	61.17	-149.985365	0	0	8	16	161	ANCHORAGE, ALASKA	40
4	4	70.13	-143.634770	0	0	8	16	161	BARTER ISLAND, ALASKA	6
5	5	53.85	-166.5346475054	8	15	151	151	DUTCH HARBOR, ALASKA	3	
6	6	64.82	-147.874870	0	0	8	16	161	FAIRBANKS, ALASKA	0
7	8	64.85	-147.584660	0	0	8	16	161	FAIRBANKS, ALASKA, LADD AFB	138
8	9	64.67	-147.104668	0	0	8	16	161	FAIRBANKS, ALASKA/EIELSON AFB	128
9	10	58.37	-134.584870	0	0	8	16	161	JUNEAU, ALASKA APT	7
10	11	64.50	-165.434570	0	0	8	16	161	NOME, ALASKA	7

⋮

267	1001	52.32	4.78	0	0	0	0	8	16	142	AMSTERDAM, NETHERLANDS	5
268	1002	52.10	5.18	0	0	0	0	8	16	162	DEBILT	10
269	1003	52.07	5.92	0	0	0	0	8	16	162	DEELEN	172
270	1004	52.97	4.80	0	0	0	0	8	16	162	DEN HELDER	18
271	1005	53.13	6.58	0	0	0	0	8	16	162	EELDE	16
272	1006	51.55	4.95	0	0	0	0	8	16	162	GILZE	39
273	1007	51.93	3.67	0	0	0	0	8	16	162	GOERCE LIGHTSHIP	10
274	1008	53.20	5.784959	0	0	0	0	8	16	162	LEEWARDEN	5
275	1009	53.48	5.13	0	0	0	0	8	16	162	TERSHELLING LIGHTSHIP	10
276	1010	53.02	4.37	0	0	0	0	8	16	162	TEXEL LIGHTSHIP	10
277	1011	52.08	4.30	0	0	0	0	8	16	152	THE HAGUE	13

⋮

2113	274	61.00	-65.0018541973	2	2	23	0
2114	275	64.00	-53.0018541973	2	4	43	0
2115	276	65.00	-9.0018541973	2	4	43	0
2116	277	61.00	-4.0018541973	2	4	43	0
2117	278	66.00	10.0018541973	2	4	43	0
2118	279	70.00	33.0018541973	2	4	43	0
2119	280	54.00	-440.0018541973	2	4	43	0
2120	281	68.00	-38.0018541973	2	4	43	0
2121	282	57.00	-26.0018541973	2	4	43	0
2122	283	57.00	-11.0018541973	2	4	43	0
2123	284	57.00	2.0018541973	2	4	43	0

⋮

OUTPUT: All data archived in a common format

FORMATS: Data are tabulated into a single common format but remain as three separate files that are now called RUSARC, NISARC, and SEAARC. (DATARC is a fourth file to be discussed in the next section.) Table 3 lists the data associated with the first station found in each file.

A header line, the first line of each group of data, contains station identification parameters that are read using the format statement described below:

COLUMN	VARIABLE	FORMAT	DESCRIPTION
1 - 5	IREC	I5	Record Number
6 - 10	ISTA	I5	Burger Station Number
11 - 16	XLAT	F6.2	Latitude (+ NORTH; - SOUTH)
17 - 23	XLON	F7.2	Longitude (+ EAST; - WEST)
24 - 31	IPOR	4I2	Period of record right justified for RUSARC, NISARC, and DATARC (year 72 = 1972)  SEAARC POR is in whole years (1972)
32 - 33	NL	I2	Number of data lines for this station
34 - 39	ICM, ICS	2I3	ICM = Number of mean values ICS = Number of scale distance values
40	IC	I1	CODE1 specifying RUSARC data CODE2 specifying NISARC data CODE3 specifying SEAARC data CODE4 specifying DATARC data
41 - 73	STNAME	3A10,A3	STATION NAME
74 - 79	IEL	I6	Station elevation in meters above sea level

TABLE 3. MEAN AND SCALE DISTANCE PARAMETER ARCHIVE (FINAL)

RUSARC

1	1	31.27	-85.725470	0	0	8	16	161	FORT RUCKER, ALABAMA										93
M	1	31.27	-85.721	560	0	0	450	0	0	380	0	0	320	0	0				
S	1	31.27	-85.721	334	0	0	277	0	0	124	0	0	319	0	0				
M	1	31.27	-85.727	660	0	0	620	0	0	640	0	0	460	0	0				
S	1	31.27	-85.727	255	0	0	189	0	0	87	0	0	217	0	0				
M	1	31.27	-85.720	660	0	0	630	0	0	730	0	0	490	0	0				
S	1	31.27	-85.720	181	0	0	118	0	0	44	0	0	146	0	0				
M	1	31.27	-85.72J	570	0	0	510	0	0	770	0	0	380	0	0				
S	1	31.27	-85.72J	255	0	0	154	0	0	76	0	0	212	0	0				

NISARC

267	1001	52.32	4.78	0	0	0	0	8	16	142	AMSTERDAM, NETHERLANDS										5
M	1001	52.32	4.781	680	0	0	520	0	0	560	0	0	550	0	0						
S	1001	52.32	4.781	0	0	0	295	0	0	172	0	0	245	0	0						
M	1001	52.32	4.787	710	0	0	660	0	0	690	0	0	660	0	0						
S	1001	52.32	4.787	198	0	0	129	0	0	127	0	0	157	0	0						
M	1001	52.32	4.780	250	0	0	650	0	0	680	0	0	700	0	0						
S	1001	52.32	4.780	0	0	0	87	0	0	85	0	0	124	0	0						
M	1001	52.32	4.78J	710	0	0	550	0	0	600	0	0	630	0	0						
S	1001	52.32	4.78J	198	0	0	116	0	0	110	0	0	120	0	0						

SEAARC

2113	274	61.00	-65.0018541973	2	2	23											0
M	274	61.00	-65.000	0	0	0	0	0	660	0	0	660	0	0			
S	274	61.00	-65.000	0	0	0	0	0	138	0	0	106	0	0			

DATARC

2335	10803	48.00	7.857382	0	0722882884	FREIBURG GERM.										300
M	10803	48.00	7.850	781	672	646	546	567	621	561	472	464	669	688	759	
S	10803	48.00	7.850	192	194	130	164	139	98	119	105	146	148	190	173	
P	10803	48.00	7.850	196	190	204	200	204	196	207	211	209	230	208	233	
M	10803	48.00	7.851	739	694	625	565	594	591	545	470	476	687	687	740	
S	10803	48.00	7.851	177	182	169	182	142	131	127	123	135	161	203	193	
P	10803	48.00	7.851	299	274	306	290	304	295	299	307	296	303	289	295	
M	10803	48.00	7.852	800	708	647	549	555	562	566	476	443	682	718	747	
S	10803	48.00	7.852	184	184	156	187	185	134	141	122	177	141	201	181	
P	10803	48.00	7.852	193	181	204	197	206	195	200	203	201	231	207	237	
M	10803	48.00	7.853	788	717	648	568	574	577	554	468	475	685	694	773	
S	10803	48.00	7.853	168	198	151	200	189	124	153	123	200	137	210	175	
P	10803	48.00	7.853	196	186	204	194	209	199	197	207	199	235	212	240	
M	10803	48.00	7.854	773	693	673	581	609	620	583	482	481	696	702	766	

Two keyworded lines of data then follow the header lines. Keyword "M" denotes a line containing mean sky cover values in integer format for each of twelve months starting with January. Keyword "S" denotes a line of data consisting of scale distance parameters in integer form. A detailed description of the format for keyworded data lines follows:

COLUMN	VARIABLE	FORMAT	DESCRIPTION
1 - 5	KEYWORD	4X, A1	Keyword describing type of data line M = Data for Mean Sky Cover ( $P_0 * 1000$ ) S = Data for Scale Distance ( $r * 100$ ) P = Data for population values
6 - 10	ISTA	I5	Burger Station Number
11 - 16	XLAT	F6.2	Latitude (+ NORTH; - SOUTH)
17 - 23	XLON	F7.2	Longitude (+ EAST; - WEST)
24	IT	A1	Local Standard Time - 0 1 2 3 4 CODED - 0 1 2 3 4 5 6 7 8 9 10 CODED - 5 6 7 8 9 A 11 12 13 14 CODED - B C D E 15 16 17 18 CODED - F G H I 19 20 21 22 23 CODED - J K L M N
25 - 72	DATA(J)	12I4	Keyword M: data are mean sky covers for each of 12 months starting with JAN Keyword S: data are scale distances for each of 12 months starting with JAN Keyword P: data are populations

Note: Columns set to zero indicate no data

REMARKS: Population values for the DATARC file have been retained and can be distinguished from the other parameters

by the keyword "P". Population values PV for RUSARC and NISARC may be computed using the input parameter IPOR by:

$$PV = ([IPOR(2) - IPOR(1) + 1] + [IPOR(4) - IPOR(3) + 1]) * 3D.$$

Period of record for SEAARC data may be computed using:

$$PV = ([IPOR(3) * 100 + IPOR(4)] - [IPOR(1) * 100 + IPOR(2)] + 1) * 3D$$

D = Number of Days in the Month.

Finally, the entire ensemble of software and data files discussed thus far is spooled to tape M4655 for permanent retention.

4. PROGRAM NAME: DISPLD Version 1.0 6/5/87

PURPOSE: To produce global displays of data availability

INPUT: Latitude and longitude coordinates of the stations in data files RUSARC, NISARC, and SEAARC are input and plotted on world maps.

OUTPUT: Points are plotted on world maps to display the spatial distribution of data available in each file. Fig. 2 shows the global distribution of stations contained in file RUSARC. The majority of points in this file are over North America and to a lesser extent over eastern Europe and the Far East. Fig. 3 presents the distribution of stations in NISARC, showing extensive coverage over eastern Europe, India and Southeast Asia. In the Southern Hemisphere coverage is shown over South America, Africa, and Australia. The distribution of sky cover reports from ship locations is shown in Fig. 4.

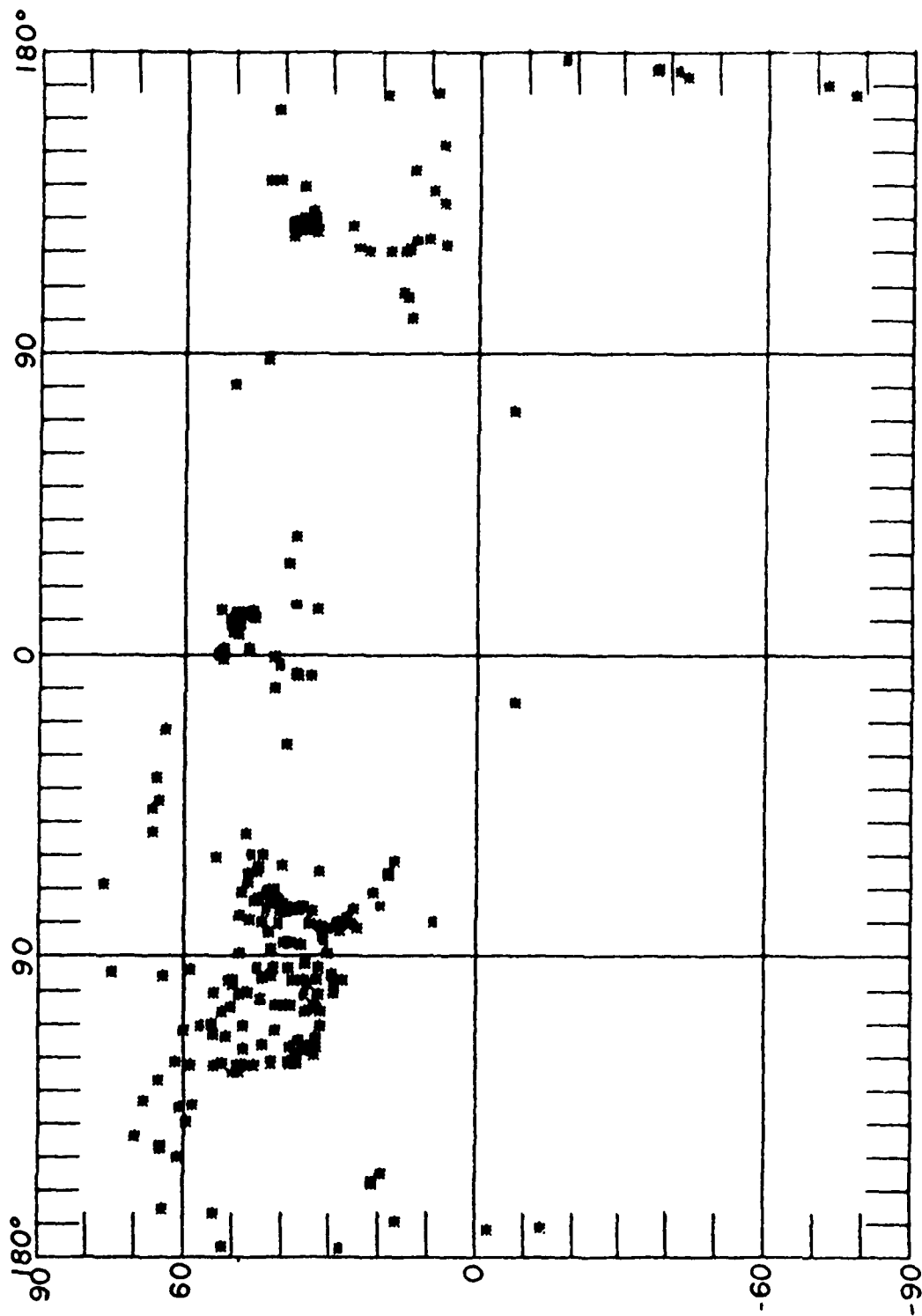


Fig. 2 Global Distribution of 266 Stations Archived in File RUSARC

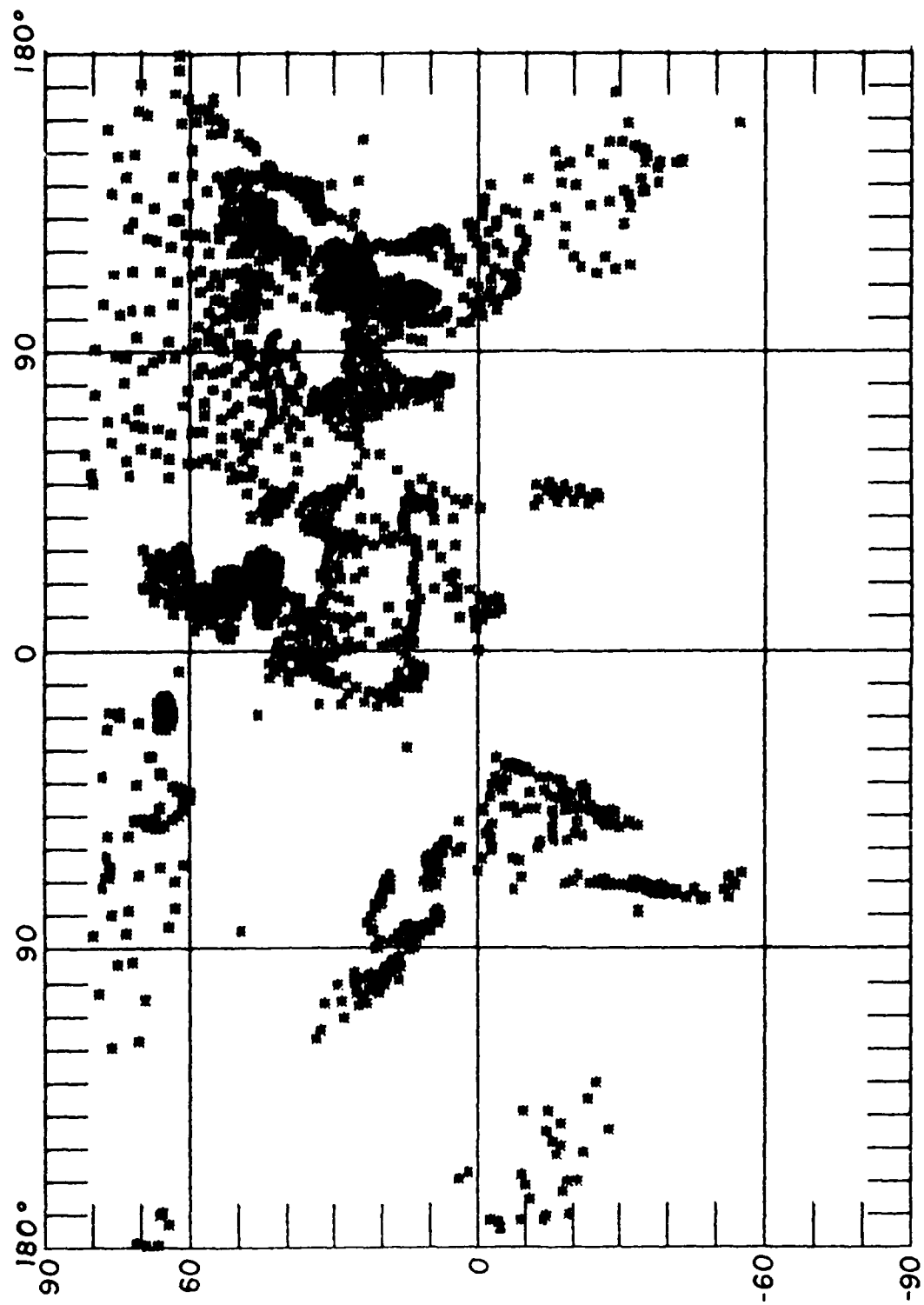


Fig. 3 Global Distribution of 1846 Stations Archived in File NISARC



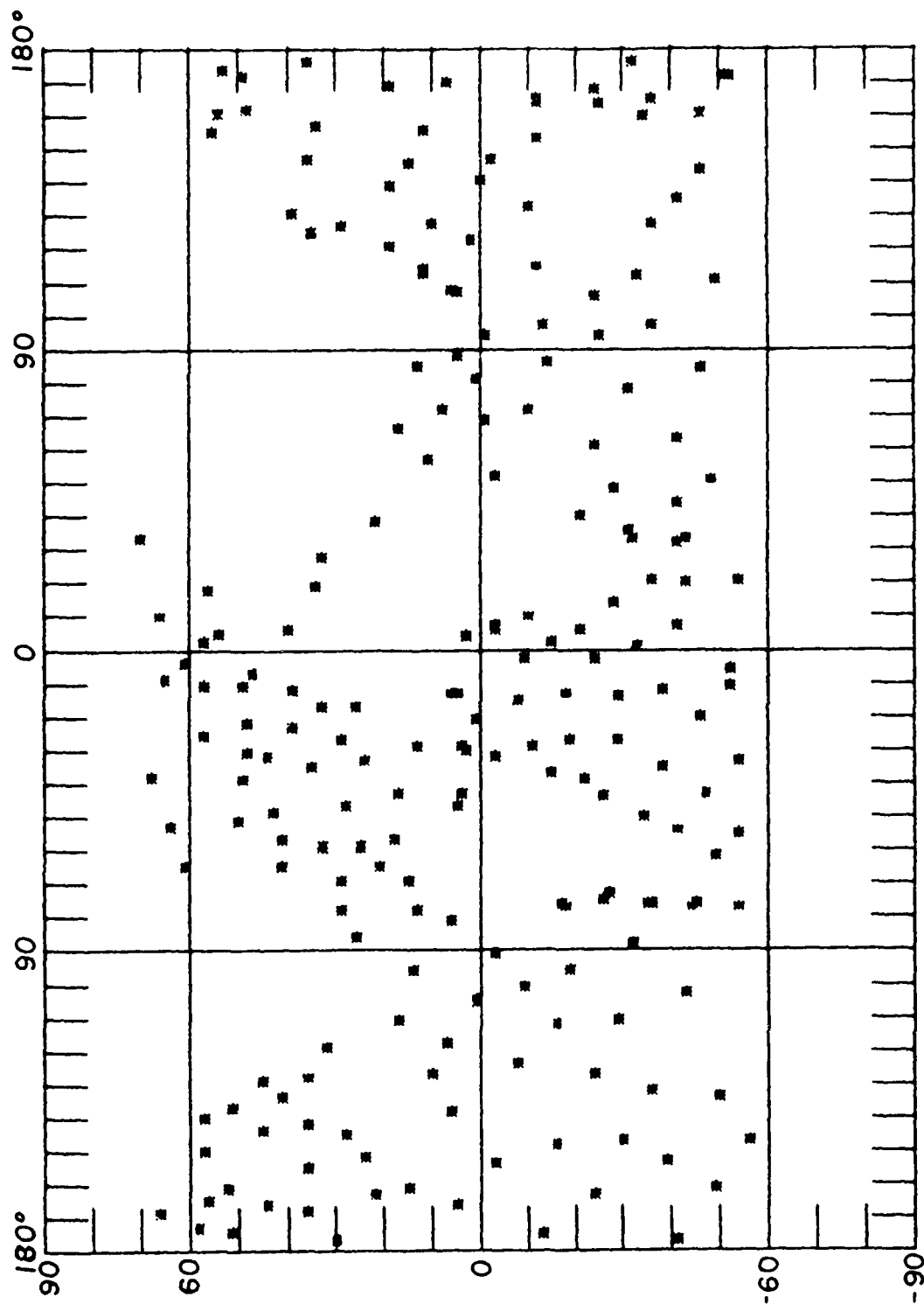


Fig. 4 Global Distribution of 222 Ship Reports Archived in File SEAARC

5. PROGRAM NAME: PLAT Version 1.0 7/10/87

PURPOSE: To plot out archived data values for data interpretation

INPUT: Mean and scale distance parameters from the final archived files

OUTPUT: Fig. 5 is a sample of the output generated by program PLAT. Mean sky cover probabilities vs. latitude from the RUSARC data file for January are displayed on the left. Scale distances have been converted to Z values using the equation below and are plotted on the right side of Fig. 5.

Scale distance may be scaled uniformly by:

$$Z = \frac{\ln \left( \frac{\sqrt{A}}{r} \right)}{\ln 2}$$

where:

A is the sky dome area constant (2,424 km<sup>2</sup>), and  
r is the scale distance.

Data plotted for different local standard times are distinguished by symbols defined at the top of the figure.

#### B. Description of DATSAV Data Processing

Hourly meteorological observations in the form of magnetic tapes for sixty-six weather stations were acquired from the U.S. Air Force Environmental Technical Applications Center (USAFETAC). These data were useful not only for providing hourly mean and scale distance parameters but were also extremely useful in the study of spatial and temporal sky cover correlation. Hour to hour observations in the DATSAV data make it possible to generate contingency tables of sky cover observed at one station with the sky cover observed at another some distance away or with itself at some



predetermined later time. These data were processed and archived into final form by the programs shown in Fig. 6.

1. PROGRAM NAME: GETCOV Version 2.0 4/25/87

PURPOSE: To extract hourly sky amount observations from DATSAV data tapes and store the observations in a form suitable for subsequent processing

INPUT: Magnetic Tapes in DATSAV Format  
1600 BPI  
Nine Track  
Binary  
Standard Label Tape

OUTPUT: Hourly cloud observations densely packed in binary form for random access file manipulation on a Cyber 180/860 60-bit computer

REMARKS: The ground observed meteorological data are contained on 66 tapes covering selected line-oriented (located along a fixed directional line) stations over eastern Europe, Australia, South America, Hawaii, Alaska, and central U.S. The data, including documentation of DATSAV format (Reference Manual, 1977), cover the period 1973-1983.

Each tape contains surface observations for a single station. Some tapes contain data archived every hour for 24 hours a day while others archive only mandatory six-hourly GMT synoptic observations.

Sky cover data in DATSAV format are in two basic forms, synoptic code and Airways code. Synoptic code reports the total fraction of the celestial dome covered in octas (0-through 8-eighths; 9 meaning obscured), while Airways code denotes sky conditions as scattered, broken, overcast,

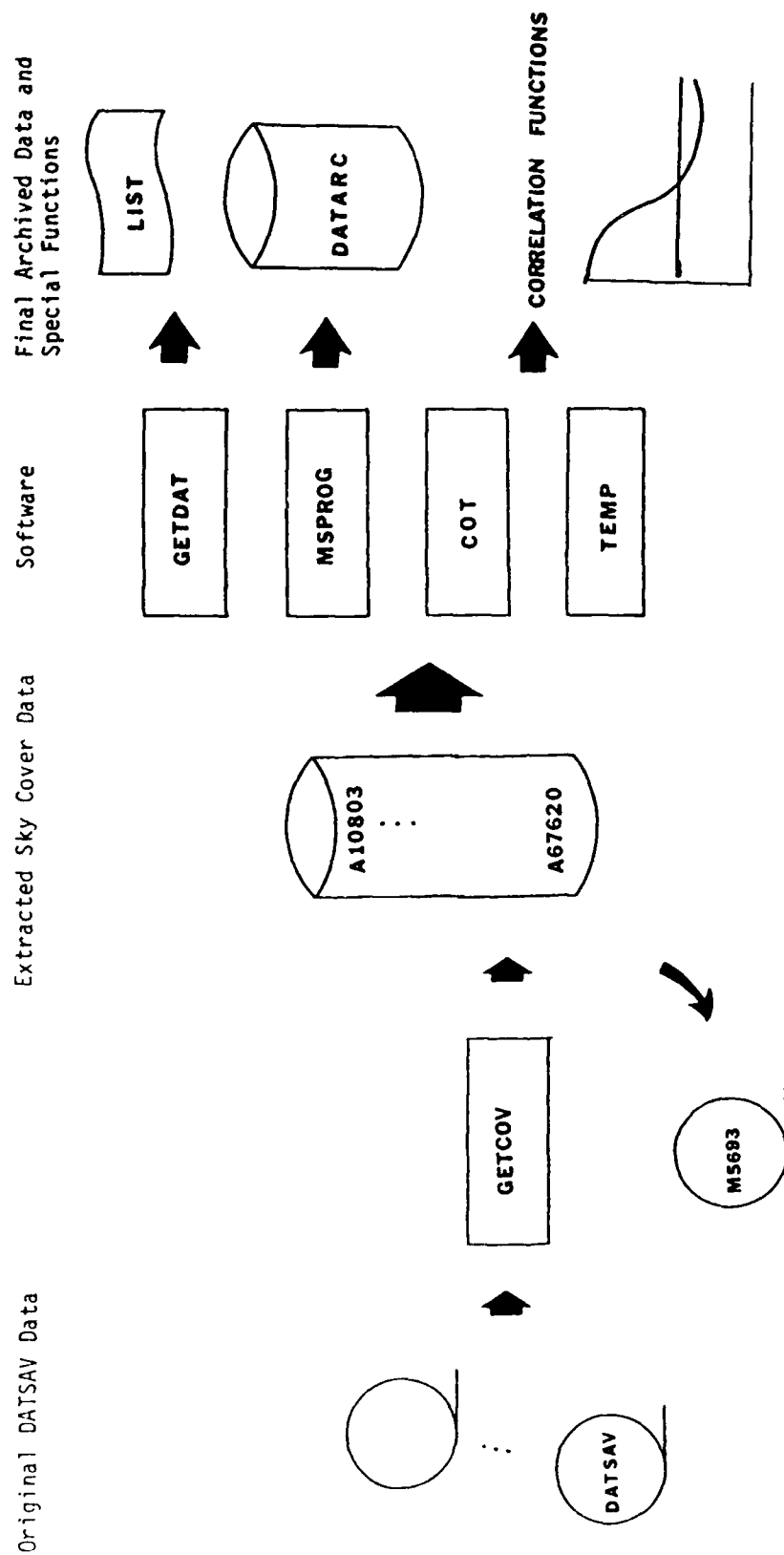


Fig. 6 DATSAV Data Processing Configuration for DATARC Archiving and Special Processing

obscured, or partially obscured. Definitions of cloud cover codes and other information are listed in Table 4.

TABLE 4. SKY COVER CODING ASSIGNMENTS

DATSAV Tape Code	Data Compaction Code	Sky Cover Conditions	Clear/Cloudy Conversion Code
Synoptic			
0	1	Clear	1
1	2	.1 octas	1
2	3	.2	1
3	4	.3	1
4	5	.4	1
5	6	.5	10
6	7	.6	10
7	8	.7	10
8	9	.8	10
9	10	Obscured	10
Airways			
0	1	Clear	1
-2	12	Scattered	1
-7	13	Broken	10
-8	14	Overcast	10
-9	15	Obscured	10
-10	16	Partially Obscured	1
65535	31	Missing Data	31

Program GETCOV converts the incoming sky cover codes to data compaction codes shown in Table 4. The largest compaction code number is 31 or 37 to the base eight which can be contained in a five-bit byte. Since the mainframe computer being utilized is a 60-bit word addressable machine, 12 five-bit bytes can fit in one word. Two words can then be used to store 24 five-bit bytes or one day (24 hours) of sky cover observations. Sixty-two words (2 X 31 days) will hold an entire month of observations. Adding two more words for station numbers and latitude-longitude locators brings the total number of words to 64, which becomes a single physical record length for one month's data. Final size of a random access data set required to store all sky cover observations

for a single station is 132 records (12 mos X 11 yrs). The compacted data sets are stored for further processing under file directory names, such as A10803, meaning data from block 10 in West Germany for station number 803, Freiburg, Germany.

Finally, all compacted sky cover data sets are spooled onto magnetic tape M5693 for permanent retention.

2. PROGRAM NAME: GETDAT Version 1.0 9/15/85

PURPOSE: To list out entire contents of compacted data sets derived from program GETCOV for quality assurance and data availability statistics

INPUT: Compacted random access data sets created by program GETCOV (see Subroutine RGETDT, pp. 29-30)

OUTPUT: Hourly sky cover observations extracted from DATSAV data tapes are printed out for data verification and availability statistics.

3. PROGRAM NAME: MSPROG Version 1.0 1/5/87

PURPOSE: To derive mean sky cover, scale distance, and population parameters from compacted DATSAV sky amount observations for further data archiving

INPUT: Compacted sky amount observations assembled by program GETCOV (see Subroutine RGETDT, pp. 29-30)

OUTPUT: DATARC Archive

REMARKS: Program MSPROG contains the routines for computing means and scale distance parameters from sky amount frequency distributions that are categorized by eighths or by Airways code.

Hourly means and scale distance were processed and archived in the same format as the Burger data (see DATARC Table 3). The keyword "P" was added so that population counts could be included in the data set. Global distribution of 66 archived DATARC stations is shown in Fig. 7.

4. PROGRAM NAME: COT Version 1.0 10/15/85

PURPOSE: To provide the logic for setting up contingency tables to compute spatial sky cover correlations

INPUT: Compacted sky amount observations assembled by program GETCOV (see Subroutine RGETDT, pp. 29-30)

OUTPUT: Spatial sky cover correlation functions

REMARKS: This version of the program uses algorithm AS87 (Martinson and Hamdan, 1975) to calculate polychoric estimates of spatial sky cover correlation. With the addition of code described by Beardwood (1977), the program will compute estimates of correlation coefficients from four-fold tables (tetrachoric correlations) as well.

5. PROGRAM NAME: TEMP Version 1.0 10/20/85

PURPOSE: To provide the logic for setting up contingency tables to compute temporal sky cover correlations

INPUT: Compacted sky cover observations assembled by program GETCOV (see Subroutine RGETDT, pp. 29-30)

OUTPUT: Temporal sky correlation functions



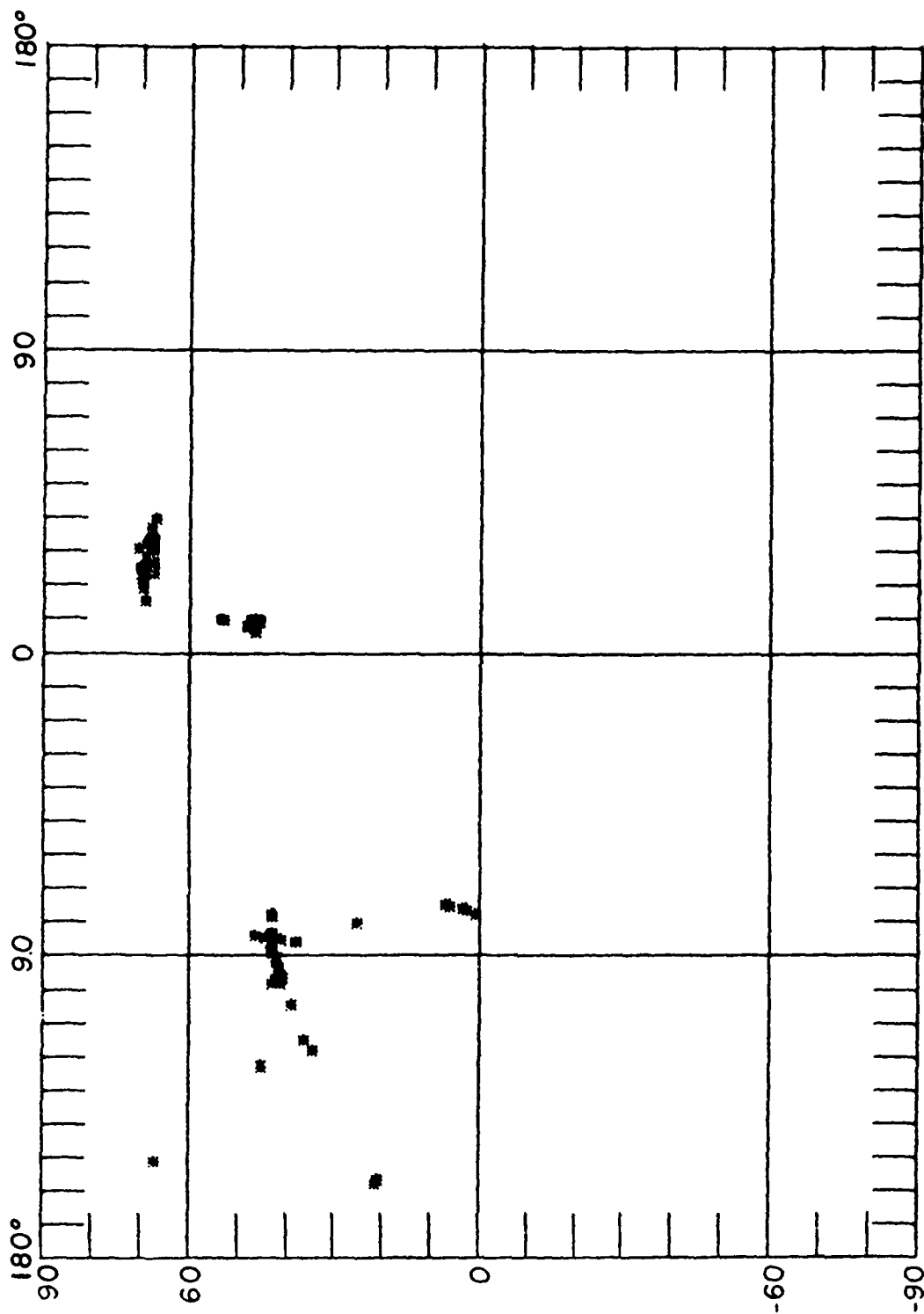


Fig. 7 Global Distribution of 66 Stations Archived in File DATARC

REMARKS: This program uses the same algorithms for computing correlation as does program COT.

6. PROGRAM NAME: Subroutine RGETDT Version 1.0 9/15/85

PURPOSE: To read compacted sky cover observations from disk

INPUT: Compacted sky cover observations are input to programs GETDAT, MSPROG, COT, and TEMP by use of this routine and the labeled common statement:

COMMON/AREA/MINDEX(145),IDT(64),IDATA(24,31),ISTA,  
XLAT,XLONG

The variables of the common area are:

MINDEX(145):	145 Physical Records Stored
IDT(64):	64 Packed Words of Information in Each Record
IDATA(24,31):	Area Used to Store 24 Hours and 31 Days of Unpacked Sky Cover Observations
ISTA:	Station Number
XLAT:	Latitude of Station
XLONG:	Longitude of Station

The OPEN statement for random access input is:

CALL OPENMS(NTAPE,MINDEX,145,0)

To read data, use the following READ statement:

CALL READMS(NTAPE,IDT,64,INDEX)

where:

INDEX is an index of the record of interest given a month and a year between 1973 and 1984.

Hence:

INDEX = (MONTH-1) + 12(YEAR-1) + 1, and  
IDT = Buffer of Size 64 Words.

All 24 sky cover observations in a day for a given month are unpacked and ready for further processing in array IDATA upon return from this routine.

### C. Description of NCAR Cloud Data Processing

The data sample of means and scale distance parameters was significantly expanded by addition of data acquired from the National Center for Atmospheric Research (Hahn, 1987). Hahn's term "cloud cover," which is used in this section (C), is synonymous with "sky cover" as used elsewhere throughout the manual. NCAR cloud information on a single tape contains global maps with typically a 5° latitude by 5° longitude grid size of long term monthly and/or seasonal total cloud cover, cloud type amounts and frequencies of occurrence, low cloud base heights, harmonic analyses of annual and diurnal cycles, inter-annual variations and trends, and cloud co-occurrences. Means and standard deviations of cloud cover observations in this data ensemble were suitably tabulated for use of Burger's algorithms to derive means and scale distance parameters at many grid points over the globe. Fig. 8 depicts the software developed to process the NCAR data for eventual integration into the C Cloud S database.

1. PROGRAM NAME: FETCH Version 1.0 8/17/87

PURPOSE: To extract selected map group climatologies from the NCAR global cloud data tape (land observations)

INPUT: Tape # M5550  
6250 BPI  
Nine Track  
ASCII  
No Label Tape

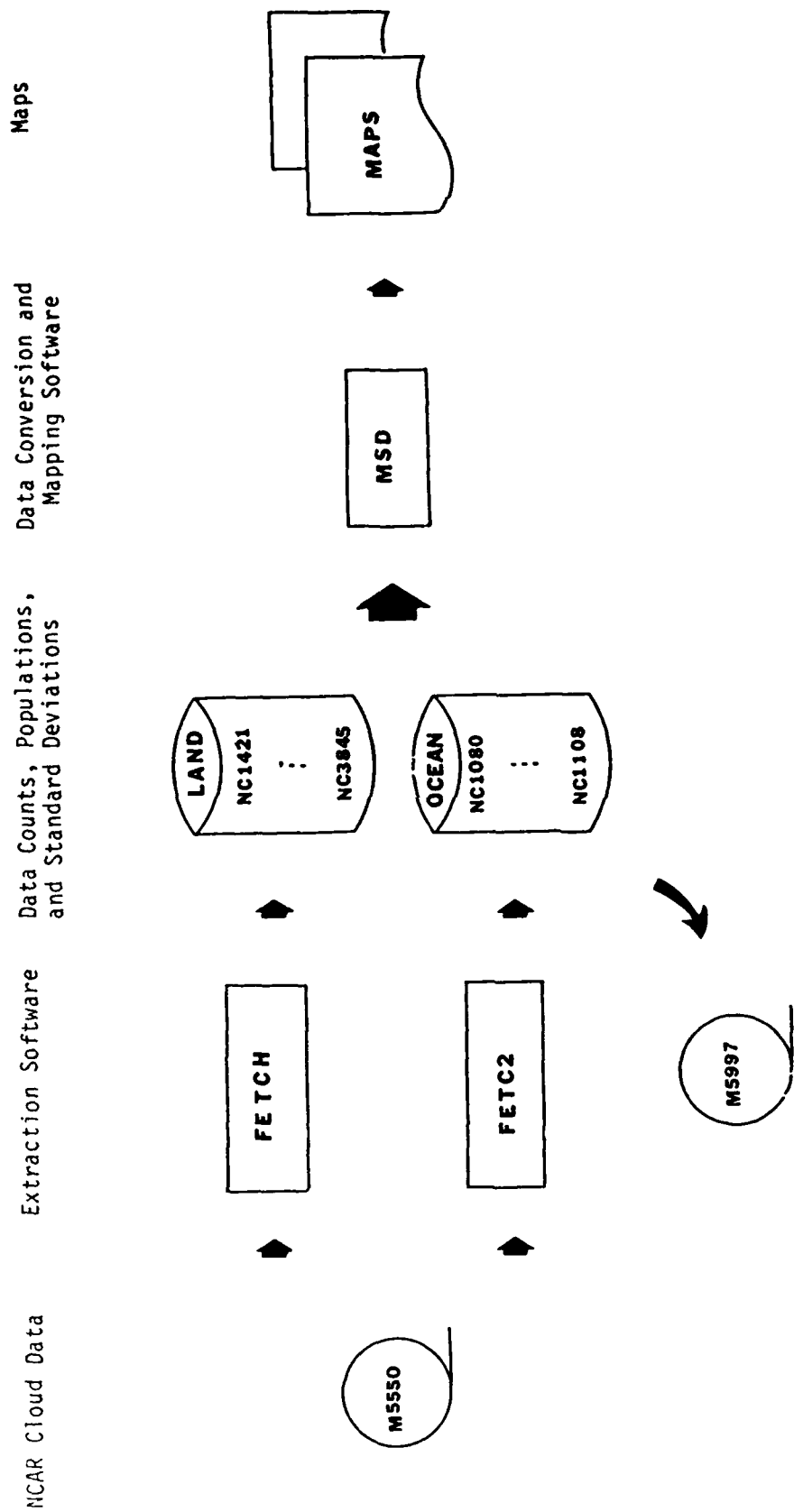


Fig. 8 Processing of NCAR Climatological Data

OUTPUT: Thirty-two map groups were extracted from the NCAR global cloud data tape and stored on permanent disk file for further processing. Each map contains mean cloud cover, standard deviation, and population counts of cloud cover observations from land stations, stratified every eight hours for four seasons. Maps are in GMT.

2. PROGRAM NAME: FETC2 Version 1.0 8/20/87

PURPOSE: To extract selected map group climatologies from the NCAR global cloud data tape (ocean observations)

INPUT: Tape # 5550 (File 6)  
6250 BPI  
Nine Track  
ASCII  
No Label

OUTPUT: Thirty-two map groups were extracted from the NCAR data tape. Each map contains mean cloud cover, standard deviations, and population counts of cloud cover observations over ocean areas every eight hours for four seasons.

REMARKS: Land and ocean maps of NCAR data on disk file are spooled to tape M5997 for permanent retention.

3. PROGRAM NAME: MSD Version 1.0 9/10/87

PURPOSE: To map mean cloud cover and scale distance parameters using NCAR cloud data

INPUT: NCAR global cloud data extracted from programs FETCH and FETC2

OUTPUT: NCAR cloud statistics are converted to mean and scale distance parameters using Burger's algorithms. The

program converts these parameters into integer values and displays the result in the form of maps. Fig. 9 is an example of a map generated showing mean cloud cover from the NCAR map group number 1080. Fig. 10 is a map of scale distances scaled to Z values and displayed in integer format. REMARKS: The standard deviation SD in the NCAR data had to be adjusted in order to use Burger's algorithms to compute scale distance correctly. The adjustment to the NCAR standard deviation used is:

$$SD = SD' * \frac{(N - 1)}{N}$$

where:

SD' is the NCAR standard deviation at a grid point, and  
N is the NCAR population count at a grid point.

Grid points consisting of population counts less than ten were excluded from the analysis.

#### D. Description of 3DNEPH Data Processing

Six years of 3DNEPH data covering the period 1977 through 1982, together with documentation, were acquired from the USAF Environmental Technical Applications Center. This data ensemble contains cloud cover observations derived from earth-viewing satellite systems. Parts of this large database have been processed to investigate techniques for converting the data into means and scale distance parameters to provide sufficient coverage over data-sparse regions of the globe. Two such programs are described.

1. PROGRAM NAME: MESH4 Version 1.0 12/1/87

PURPOSE: To read and unpack 3DNEPH data tapes

360E

34





INPUT: 3DNEPH Tapes

6250 BPI

Nine Track

Binary

No Label

Global cloud cover distributions derived from earth-viewing satellite systems are densely packed onto two separate magnetic tapes, one for the Northern Hemisphere and another for the Southern Hemisphere. For each hemisphere data are stored in a one-eighth mesh AFGWC (Air Force Global Weather Central) grid consisting of 512 X 512 array elements. According to Fye (1978) the grid system used for the 3DNEPH is a subset of the basic horizontal AFGWC 200 nm macroscale grid. This subset is one-eighth of the 200 nm grid, resulting in an average grid spacing of approximately 25 nm.

OUTPUT: Because of the large volume of data on each 3DNEPH tape, output of unpacked cloud cover observations from these tapes is currently stored onto a second tape. The unpacked data are utilized in the development of algorithms to convert the data into mean and scale distance parameters.

FORMATS: 3DNEPH data are unpacked and formatted onto a second tape in the following formats:

```
WRITE(NTAPE,100) IY,MO,MH,JJ1,JJ2,II1,II2
100 FORMAT(1X,3I2,4I4)
```

The variables of this header record are:

IY: Two-digit Year

MO: Month of Year

MH: GMT Hour of Observation

JJ1: J Coordinate of Grid Cell (1st value)

JJ2: J Coordinate of Grid Cell (2nd value)

III1: I Coordinate of Grid Cell (1st value)  
II2: I Coordinate of Grid Cell (2nd value)

Data for seventeen grid cells are then written in the following format:

```
DO 50 K=1,17  
WRITE(NTAPE,101) (ID(J),J=1,22)  
50 CONTINUE
```

The variable ID is defined as:

ID(1): Total Cloud Amount  
ID(2) thru ID(22): Data for 21 Cloud Amount Categories

2. PROGRAM NAME: PROC Version 1.0 12/15/87

PURPOSE: To locate and output portions of unpacked 3DNEPH data for investigation

INPUT: 3DNEPH data generated by program MESH4, and selected grid cell numbers

OUTPUT: I and J grid cell coordinates for selected 3DNEPH grid cells are converted to latitude, longitude coordinates and displayed together with cloud cover data associated with each cell.

FORMATS: Data are read using the same formats as for program MESH4.

### III. PROTOTYPE SOFTWARE FOR MAPPING GLOBAL SKY COVER

Section II of this report documents the development of a database containing means and scale distance parameters. This section describes the application of that database to produce maps of global sky cover.

One approach to mapping sky cover on a global scale, given two types of parameters randomly spaced over the globe, is to devise accurate interpolation algorithms that will rapidly compute sky cover values given any point on earth. Basically, the algorithm interpolates mean and scale distance parameters in four respects: first, by day; then time of day; then by latitude and longitude. Such an algorithm is presented in this section.

1. PROGRAM NAME: TIMDAY Version 1.0 7/22/87

PURPOSE: Using a Fourier series and Choleski regression, to generate coefficients that can be used to compute or interpolate accurately mean and scale distance parameters given any day and time of day for a single location

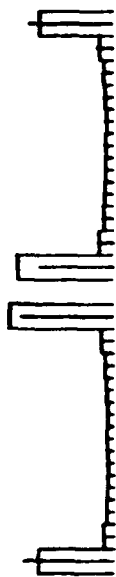
INPUT: Archived mean sky cover and scale distance parameters

OUTPUT: Several test runs were initiated to determine the optimum number of Fourier terms needed to interpolate accurately input values of mean sky cover and scale distance to any day and time of day. Fig. 11 shows the amount of error introduced into the interpolation when the number of terms used in the Fourier series is reduced or increased.

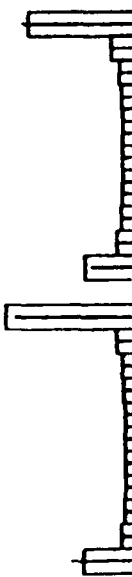
Vertical rectangular shapes in the figure represent input sky cover values and single vertical lines represent interpolated values. Tenths of sky cover shown are for Fort Rucker, AL, for the four mid-season months of January, April,

← NTERM = 2

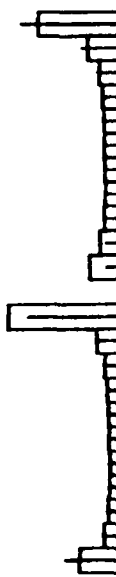
RHSE 0.0229  
HAXE 0.0434



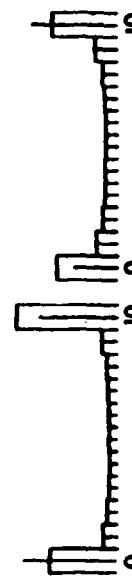
RHSE 0.0172  
HAXE 0.0359



RHSE 0.0313  
HAXE 0.0830



RHSE 0.0411  
HAXE 0.0506



← NTERM = 3

RHSE 0.0000  
HAXE 0.0000



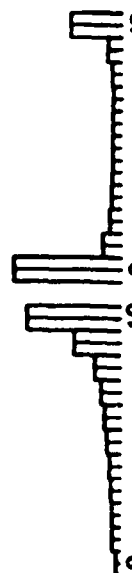
RHSE 0.0000  
HAXE 0.0000



RHSE 0.0000  
HAXE -0.0000



RHSE 0.0000  
HAXE 0.0000



STATION NO: 1 NTERM=2 31.27 -85.72

Fig. 11 Program TIMDAY Test Output Error Analysis

July, and October and for the four local standard hours 0100, 0700, 1300, and 1900. The typical error associated with a decrease in the number of Fourier terms used to generate the data is shown on the left. A near perfect fit to the data is obtained when the number of terms is larger, as evidenced by the fit on the right side of the figure.

2. PROGRAM NAME: SUNCOR Version 1.0 7/25/87

PURPOSE: To correlate mean sky cover scale distance parameters with sunrise and sunset time lines

INPUT: Archived mean sky cover and scale distance parameters from selected stations interpolated over days and times of day using program TIMDAY

OUTPUT: Sunrise and sunset time lines were computed and superimposed on the contoured sky cover parameters for visual interpretation. Fig. 12 shows results of this procedure for Fairbanks, Alaska, and Fairfield, CA.

3. PROGRAM NAME: A6060 Version 1.0 12/15/87

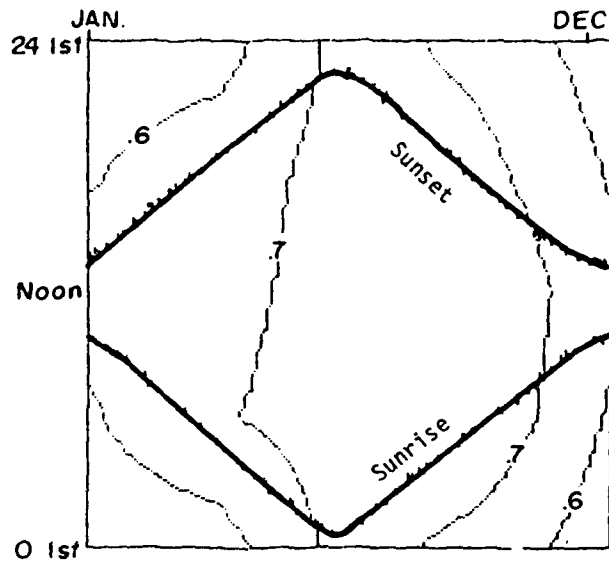
PURPOSE: To generate coefficients that can be used to compute or interpolate accurately mean sky cover and scale distance parameters for any longitude and for any latitude between  $60^{\circ}$  North and  $60^{\circ}$  South

INPUT: Archived mean sky cover or scale distance parameters and the desired number of coefficients to be computed together with a number describing the amount of input data

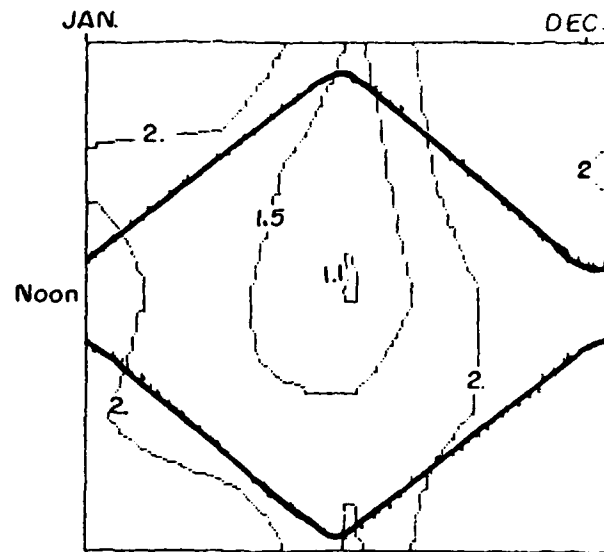
OUTPUT: Coefficients generated by program A6060 are written to a file for further processing.

# FAIRBANKS ALASKA

64.82N 147.87W



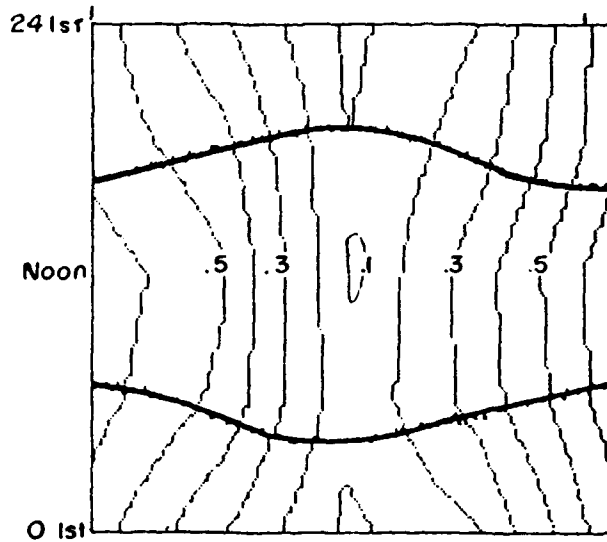
MEAN SKY COVER



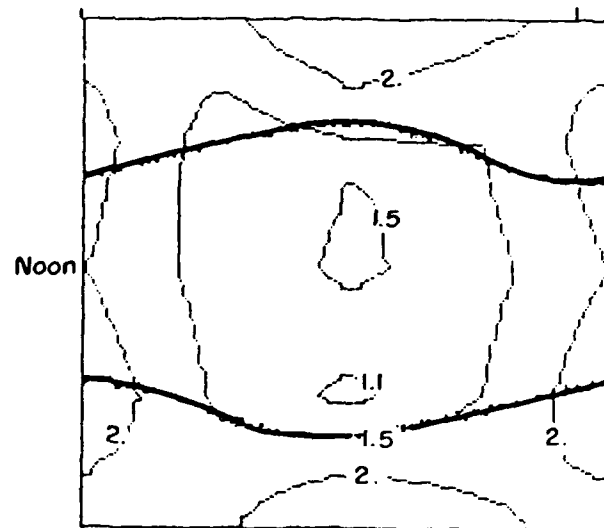
SCALE DISTANCE

# FAIRFIELD CALIFORNIA

38.27N 127.93W



MEAN SKY COVER



SCALE DISTANCE

Fig. 12 Correlation of Sunrise and Sunset with Mean Sky Cover and Scale Distance

REMARKS: The program uses a Fourier series to generate coefficients for interpolating values in the longitudinal direction. Legendre coefficients are generated to interpolate values along latitude lines.

In developing this program computer storage requirements and timing considerations were of concern. Mapping accuracy increases as the number of input values and coefficients increases. Storage requirements increase linearly with data amount but processing time increases exponentially as the number of desired coefficients increases. Input of about 500 climatologies and computation of 80 coefficients appears to be appropriate for accurate mapping.

FORMAT: Coefficients are written in the following format:

```
DO 10 J=1,NC
WRITE(NDISK,100)J,A(J)
100 FORMAT(I6,E15.4)
10 CONTINUE
```

Variables are defined as:

NC: Number of Coefficients

J: Index Counter

A: Coefficients

4. PROGRAM NAME: MAPDIS Version 1.0 12/28/87

PURPOSE: To map mean sky cover and scale distance

INPUT: Coefficients generated by program A6060 and the size of the array used to store them

OUTPUT: The coefficients are used with a Fourier series and a Legendre polynomial to produce maps of mean sky cover or scale distance on a global scale from 60° North to 60° South latitude.

**FORMAT:** Coefficients are read in the following format:

```
DO 10 J=1,NC
  READ(NDISK,100)J,A(J)
100 FORMAT(I6,E15.4)
10 CONTINUE
```

Variables are defined as:

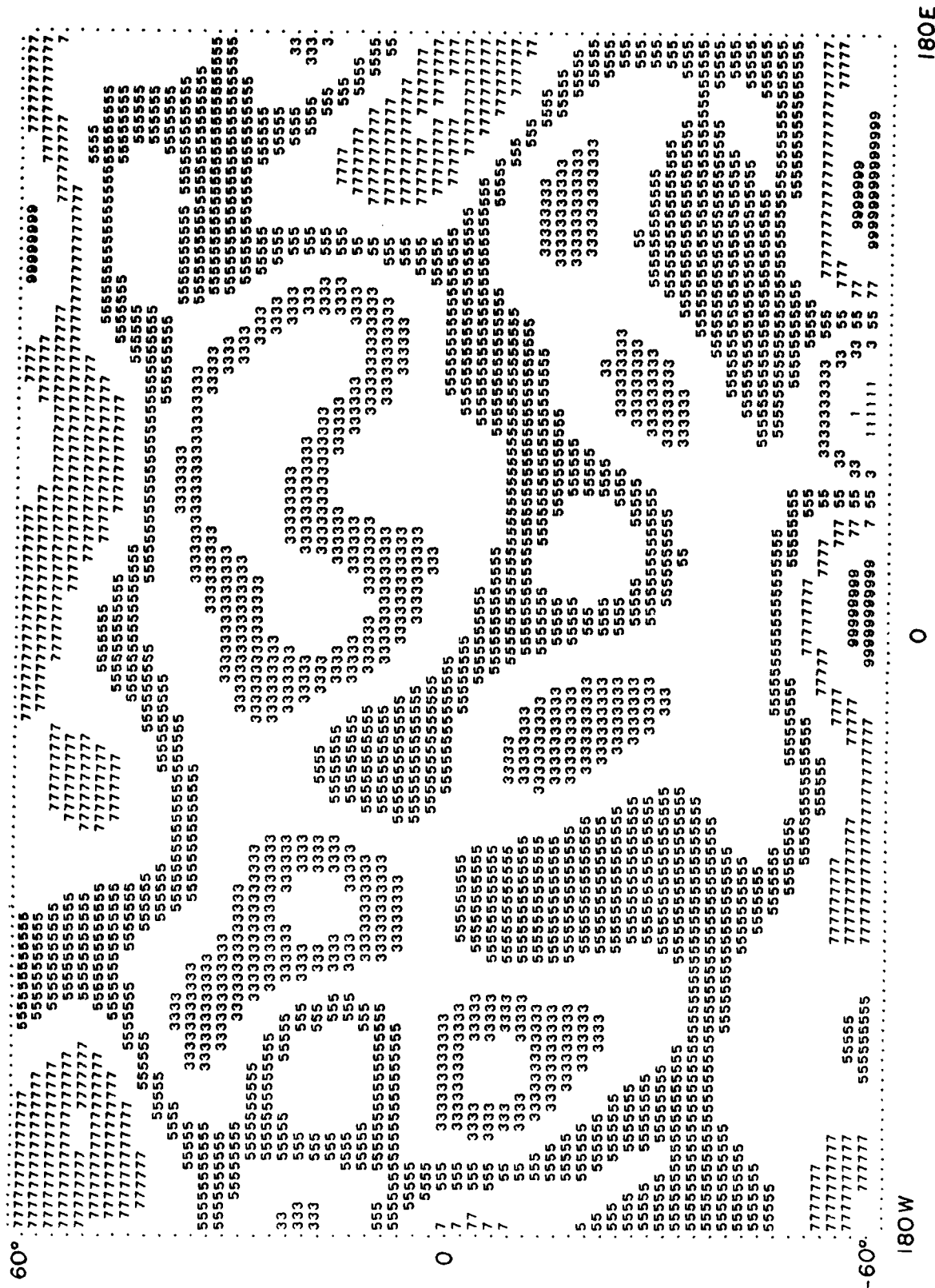
NC: Number of Coefficients

J: Index Counter

A: Coefficients

**REMARKS:** A routine called CATMAP was incorporated that uses a bilinear interpolation technique to contour data arrays into patterns that are produced on a line printer. Fig. 13 displays a map of mean sky cover generated using data from the January 0000 LST RUSARC and SEAARC files. Fig. 14 is a map of scale distance where scale distance values have been converted to Z values for presentation purposes.





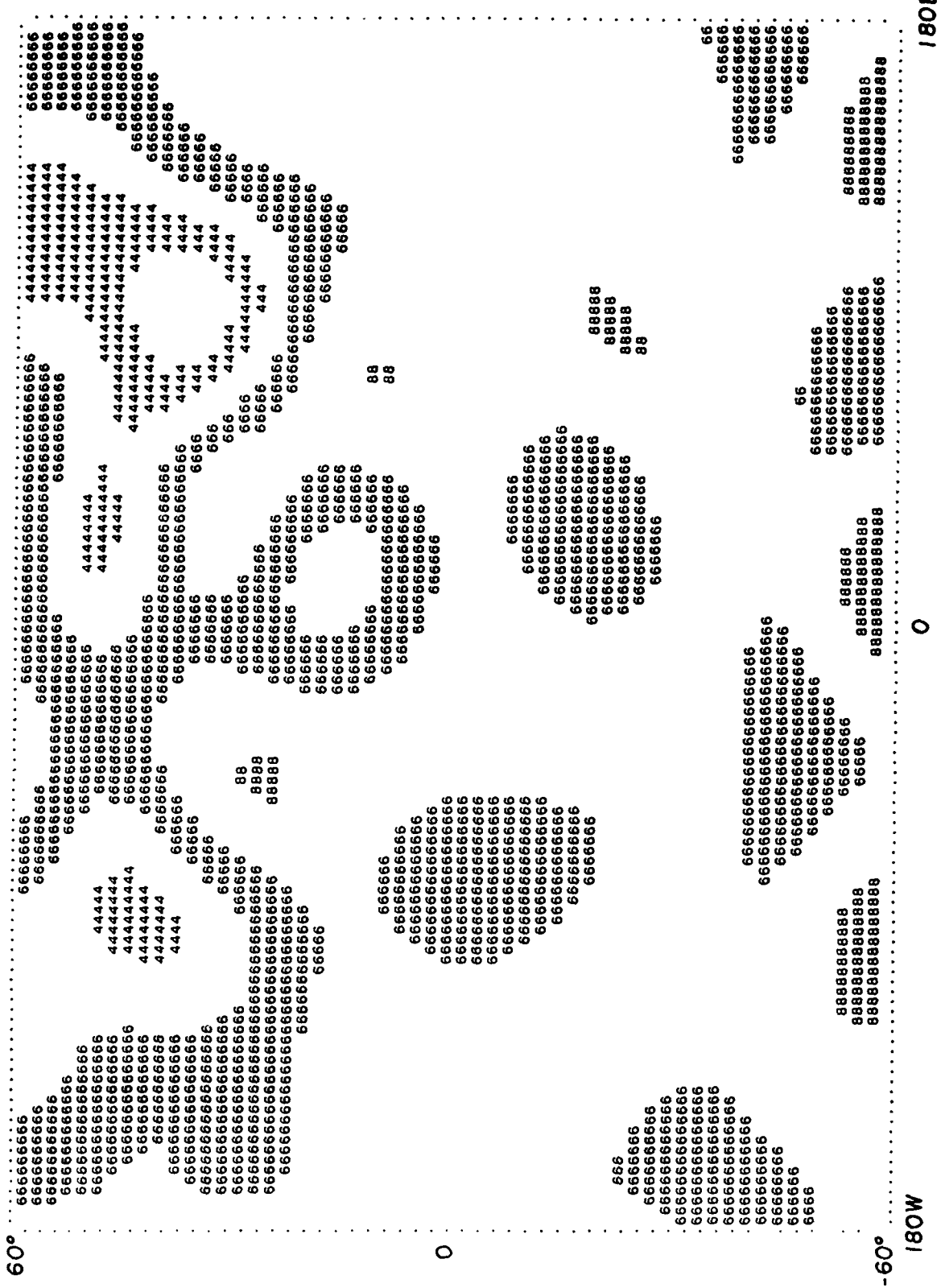


Fig. 14 Scale Distance (Z)

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